# MSDS 413, Summer 2019, Assignment 6
# Volatility Models (TS6)

## Introduction

The daily returns of Microsoft (msft) stock from January 1961 to December 2013. The data are available from CRSP and in the file d-msft3dx0113.txt Obtain the log return series of BA stock.

The following list defines the variables:

- PERMNO: price end of period
- date: year month day
- msft: daily returns
- vwretd: unused for this assignment
- ewretd: unused for this assignment
- sprtrn: unused for this assignment

The monthly returns of Boeing (BA) stock from January 1961 to December 2013. The data are available from CRSP and in the file m-ba3dx6113.txt. Obtain the log return series of BA stock.

The following list defines the variables:

- PERMNO: price end of period
- date: year month day (monthly data)
- ba: monthly returns
- vwretd: unused for this assignment
- ewretd: unused for this assignment
- sprtrn: unused for this assignment

Your objective is to explore the time series behavior of these data sets including EDA, modeling, model diagnostics, and interpretation.

## Procedure

The following steps are necessary to complete this assignment. Address each and every part and ensure that you cover all the details specified in the questions.

1. **MSFT** (3 points) Consider the daily returns ($msft$) of Microsoft stock from January 3, 2001 to December 31, 2013. A time series model of the returns is called a mean model.

1.1. Use EDA to justify a transformation of the simple returns to log returns. Is the expected log return zero? Why? Are there any serial correlations in the log returns? Why?

1.2. Write a mean model to be fitted. Build a mean equation for the log returns. Is there an ARCH effect in the log return series? Why?

1.3. Fit a Gaussian ARMA-GARCH volatity model to the log return series. Obtain the normal QQ-plot of the standardized residuals, and write the model to be fitted. Is the model adequate? Why?

1.4. Build an ARMA-GARCH model with Student-$t$ innovations for the log return series. Perform model checking and write the model to be fitted.

1.5. Obtain 1-step to 5-step ahead mean and volatility forecasts using the fitted ARMA-GARCH model with Student-$t$ innovations.

1.6. As the estimated coefficient of the mean equation is small, we may ignore the mean equation; i.e., use the mean equation $r_t = a_t$. Fit an IGARCH(1,1) model to the log returns. Write the model to be fitted.

1.7. Let $\sigma_t$ be the fitted volatility of the IGARCH(1,1) model. Define the standardized residuals as $\epsilon_t = r_t/\sigma_t$ , where $r_t$ is the daily log return. Is there serial correlation in the standardized residuals? Why?

1.8. Is there serial correlation in the squares of the standardized residuals? Why?

1.9. Based on the model checking, is the IGARCH model adequate? If yes, obtain 1-step to 4-step ahead volatility forecasts for the log return series (forecast origin is the last data point).

1.10. Which model do you recommend and why?

2. **Boeing returns** (3 points) Consider the monthly returns of Boeing (*ba*) stock.

2.1. Use EDA to justify a transformation of the simple returns to log returns. Is the expected *ba* log return zero? Why? Is there serial correlation in the log returns? Why? Is there any ARCH effect in the log returns? Why?

2.2. Build a GARCH model with Gaussian innovations for the log return series. Perform model checking and write the model to be fitted.

2.3. Fit a GARCH model with skew-Student-$t$ innovations to the log return series. Perform model checking and write the model to be fitted. Based on the fitted model, is the monthly log returns of *ba* stock skewed? Why?

2.4. Fit a GARCM-M model to the monthly log returns. Write the model to be fitted. Is the risk premium statistically significant? Why?

2.5. Fit a TGARCH(1,1) model to the monthly log returns. Write the model to be fitted. Is the leverage effect statistically significant? Why?

3. **Report** (1.5 point) Write a Boeing returns analysis executive summary.

## Deliverables

See Section Submission Directions below. The assignment deliverables, each in pdf format, are as follows:

- *Only if requested by instructor*
  - The program or script
  - Logs
  - Outputs
- Mandatory
  Data analysis write-up: no programs, logs, or just code outputs.

The data analysis must follow and use the item numbering of each assignment, i.e., use the numbers, say, 1 - 5, with the sub-lettering if used. These deliverables are provided according to the instructions in the Submission Directions section below.

## Submission Directions

### Title Page

Include a title page with your name and the assignment designation. Leave room for instructor comments.

### File Names

The assignment write-up file shall be submitted to Canvas according to the schedule in the syllabus using the item (1) naming convention below. The naming convention is case sensitive. Use letters and numbers as given. **The file name parts have no spaces or other separator charancters**.
TS6Lastname.pdf (submit via Canvas)

The parts are the assignment code, TS6; your lastname with only the first letter capitalized; a period, and lastly, the extension "pdf". Generically,

TS6Lastname.pdf

For example: Suppose your name is Student McStats. Your filename then is:

TS6Mcstats.pdf

The analysis write-up file must be submitted for grading. Each write-up requires a title page for instructor comments. The analysis may use either R or any other statistics package you wish, or if you use more than one package, you must use the germane tables, plots, etc., in a single report. If you use more than one package, differences and similarities should be indicated.

**email: jamie.riggs@northwestern.edu**

Email *ONLY IF REQUESTED* the program (script), log and output as separate pdf files. The R log and output may be combined. The file names shall be as follows:

- The program or script file names
  - TS6LastnameRprog.pdf
- The log file names
  - TS6LastnameRlog.pdf